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Nishida

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(54) **KEYBOARD APPARATUS**

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G10C 3/12 (2006.01)

(52) **U.S. Cl.** ..... **84/423 R**

(58) **Field of Classification Search** ..... 84/423 R, 84/477, 478, 430, 441, 423 A
See application file for complete search history.

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(57) **ABSTRACT**

A keyboard apparatus having a construction which can maintain an excellent balance in touch feeling between white keys and black keys and can be made compact in size in the longitudinal direction. The driven part of each of mass bodies associated with respective white keys and the driven part of each of mass bodies associated with respective black keys are at the same longitudinal location, and at the same time the distance between the driven part of each black key-associated mass body and a pivotal motion support associated therewith is longer than the distance between the driven part of each white key-associated mass body and a pivotal motion support associated therewith.

8 Claims, 8 Drawing Sheets

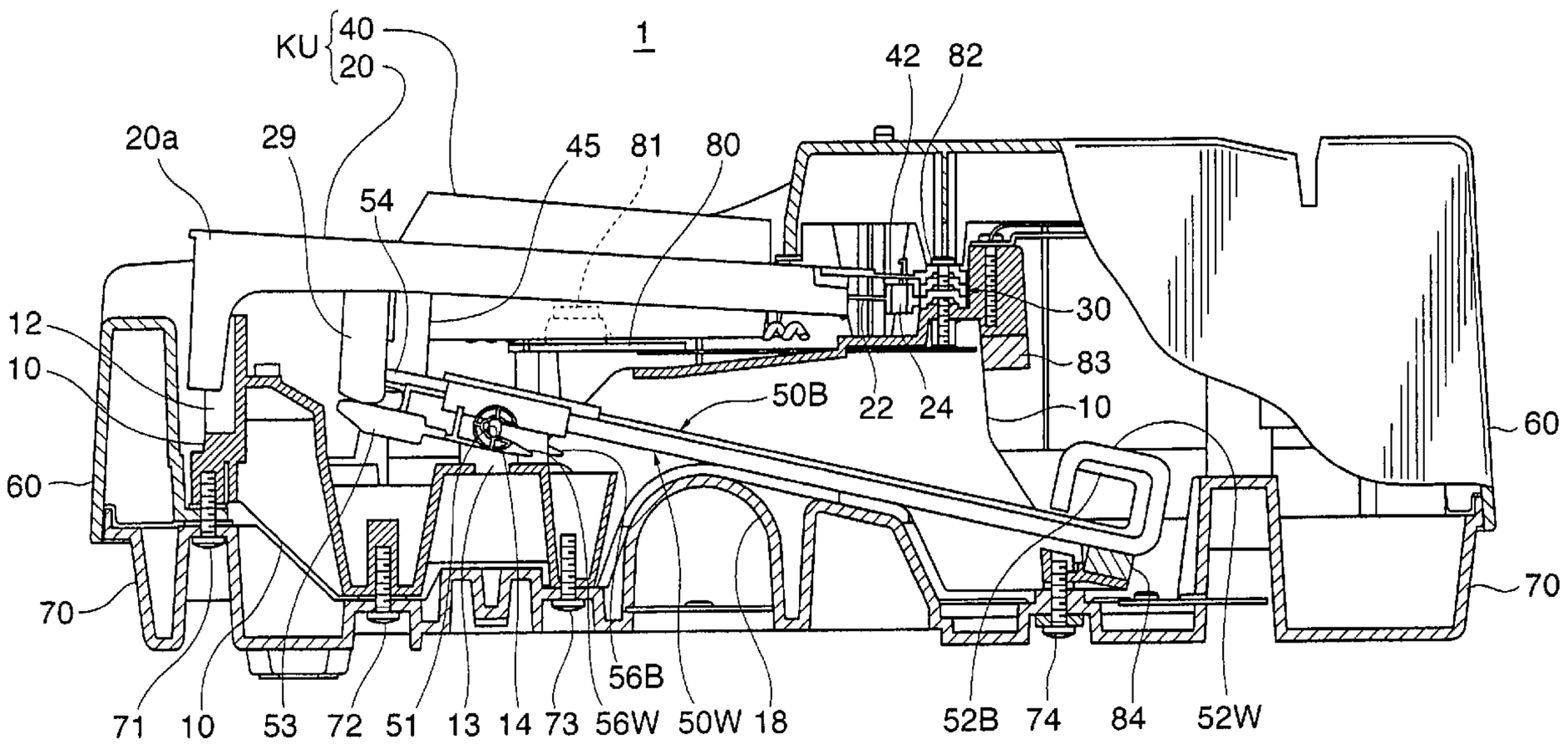
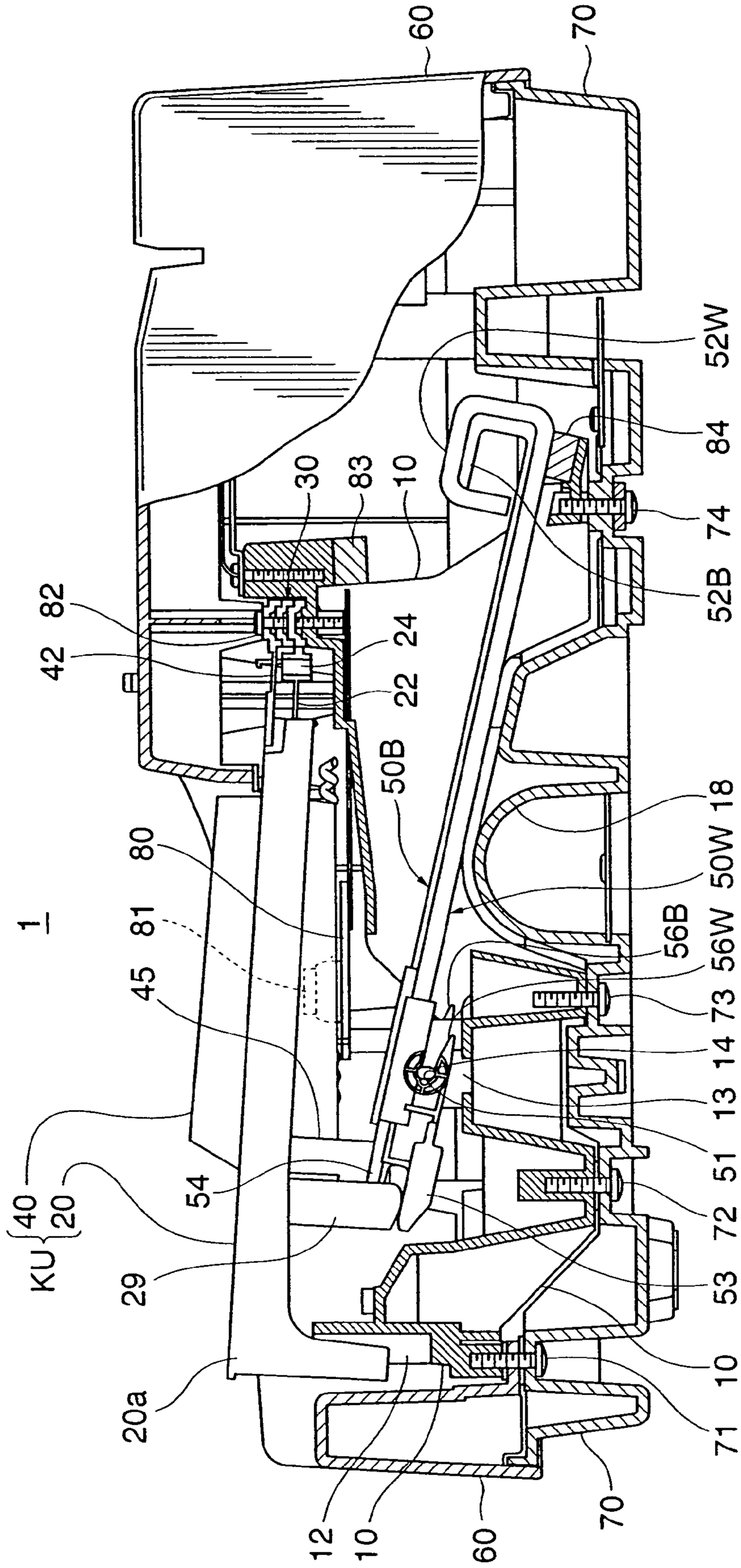


FIG. 1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KU
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70
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52B
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50W
81
56B
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60
70

FIG. 2

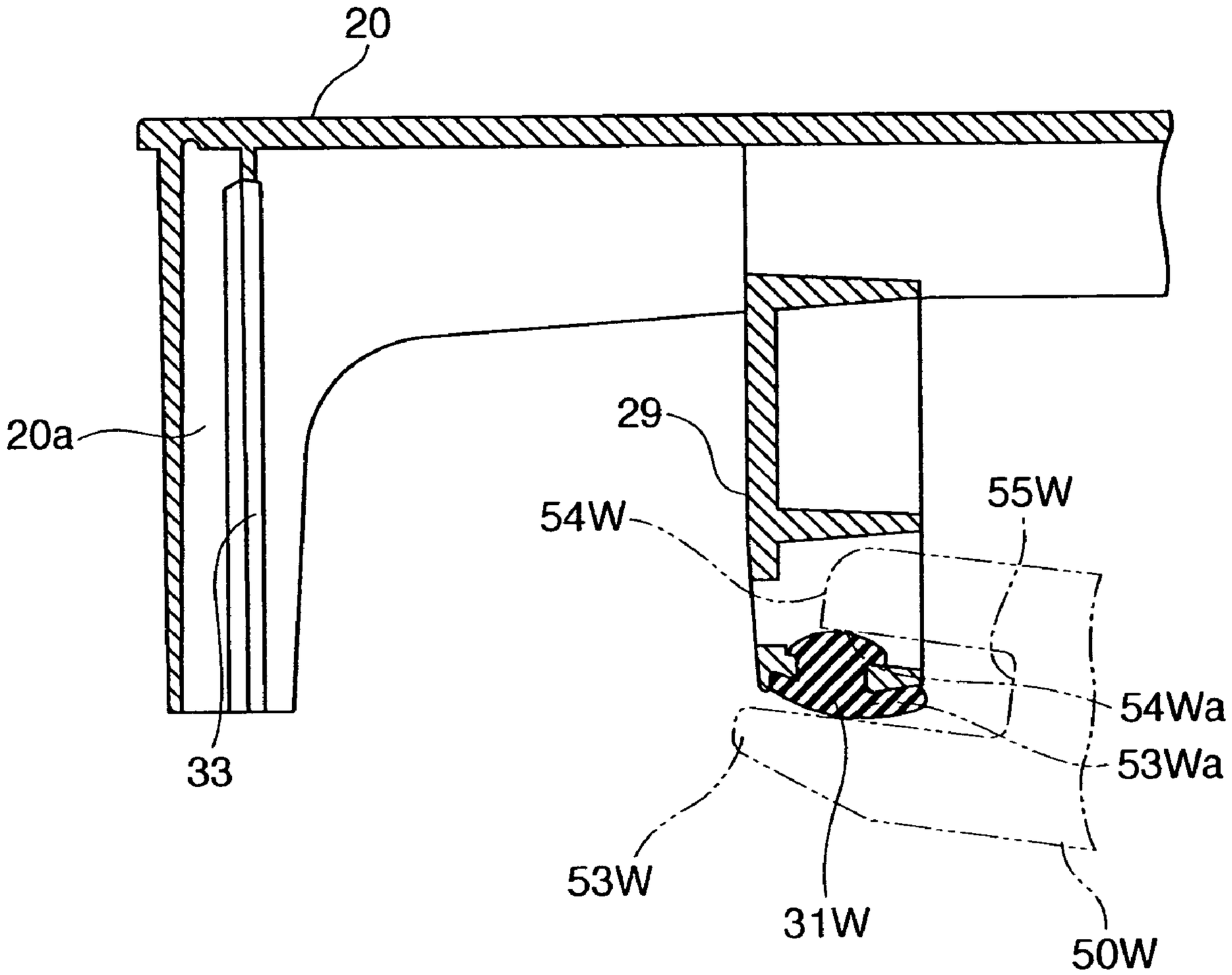


FIG. 3

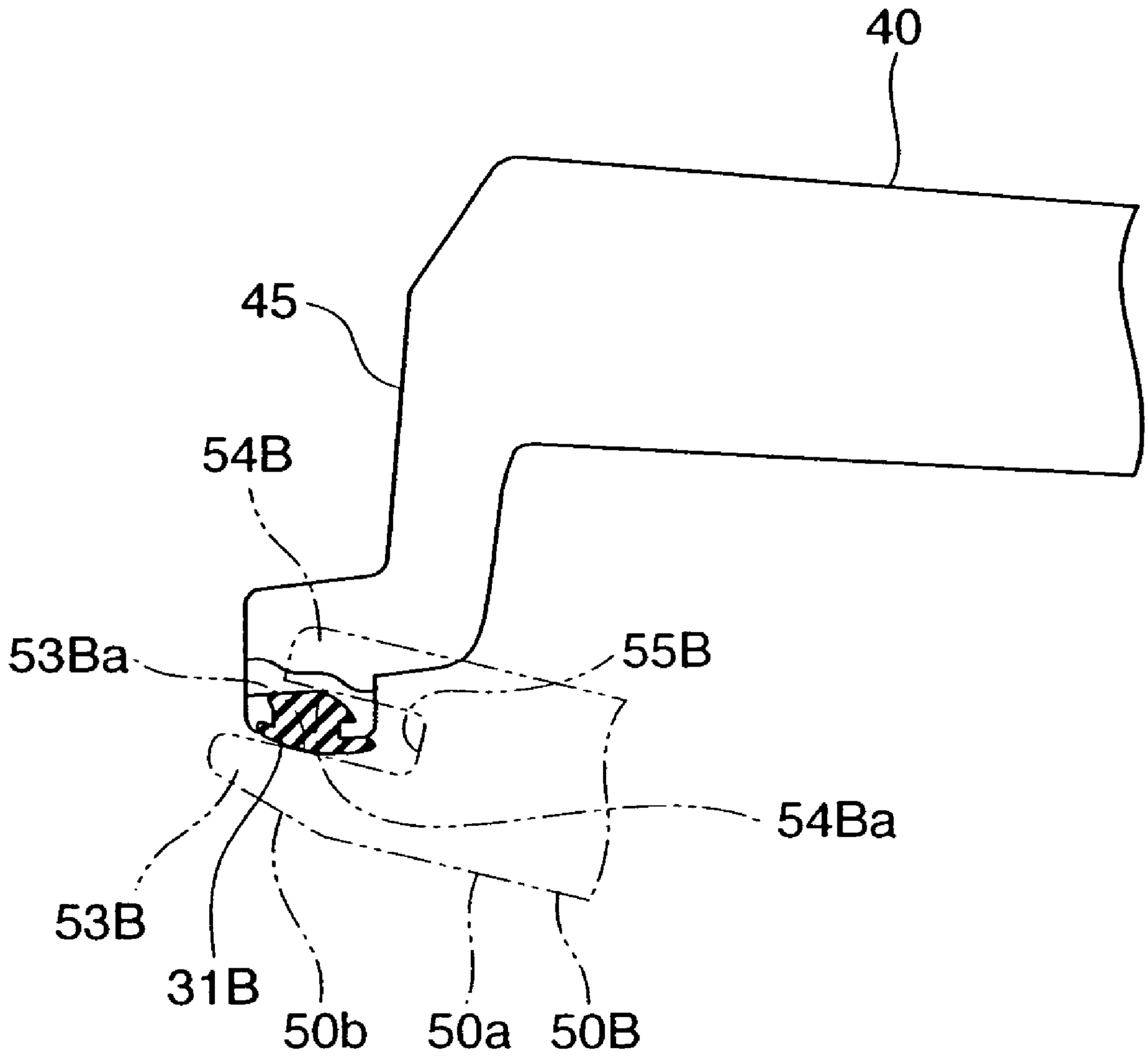
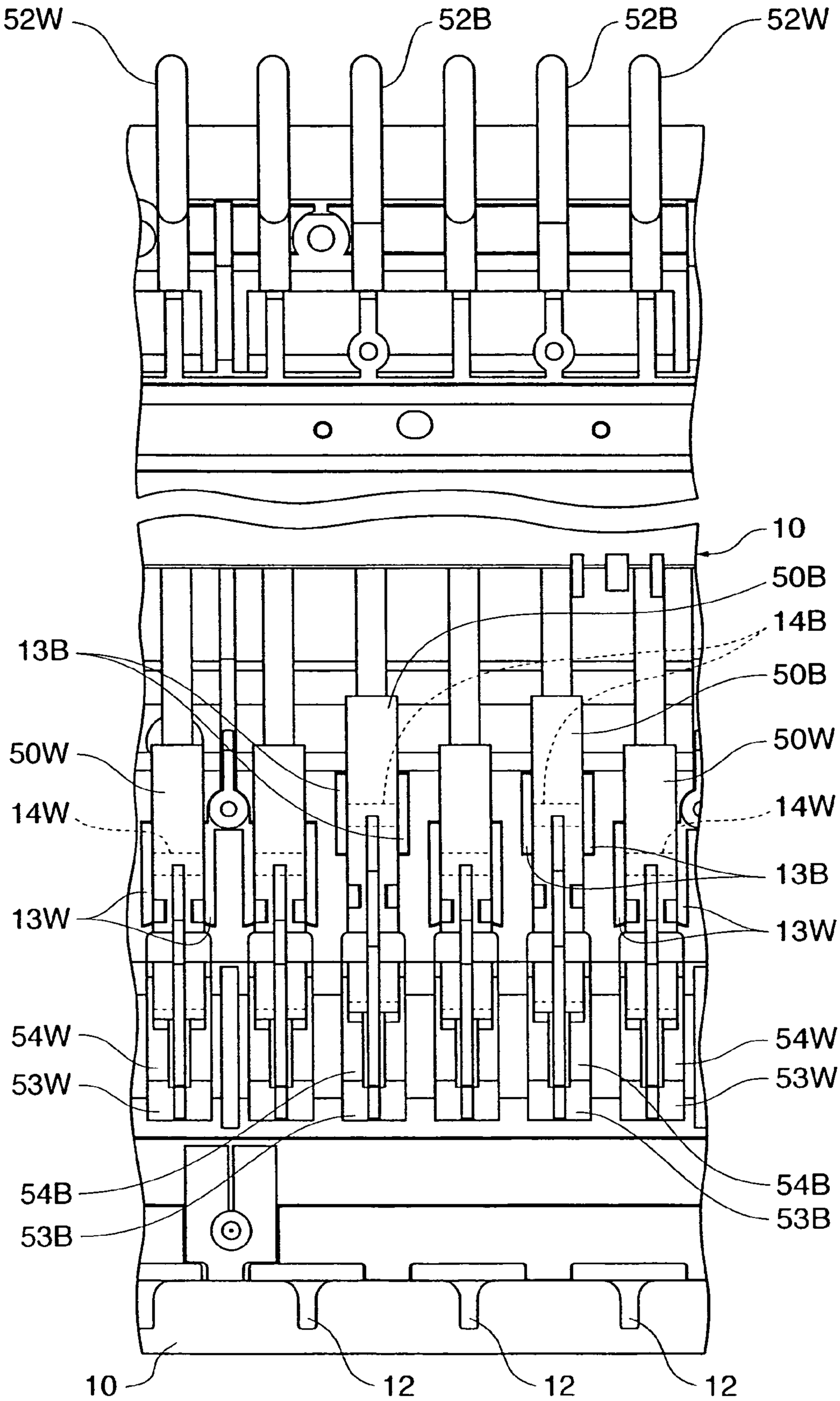


FIG. 4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52B
52B
52W
10
50B
14B
13B
50B
50W
50W
14W
14W
13B
13W
13W
54W
54W
53W
53W
54B
54B
53B
53B
10
12
12
12

FIG. 5

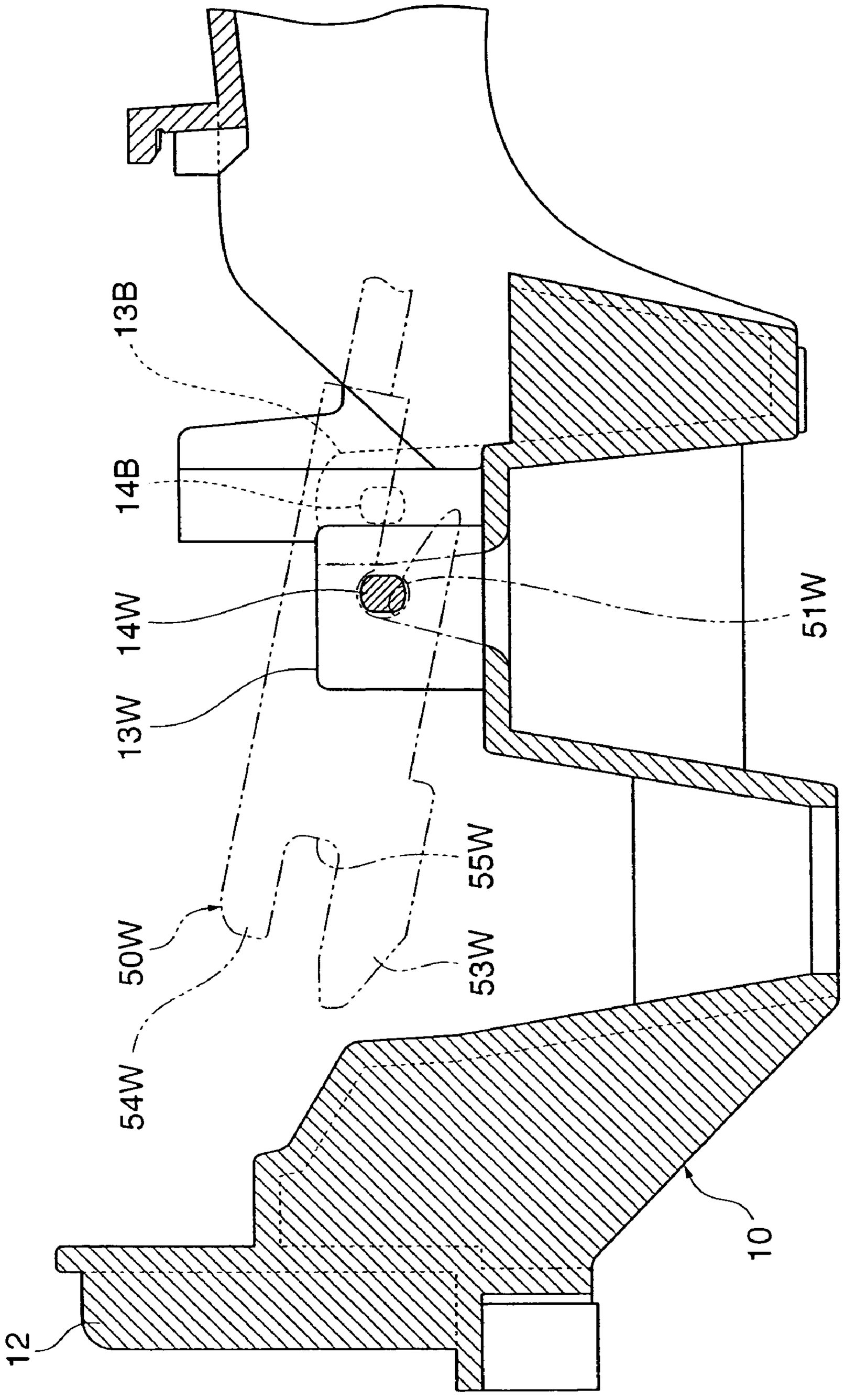


FIG. 6A

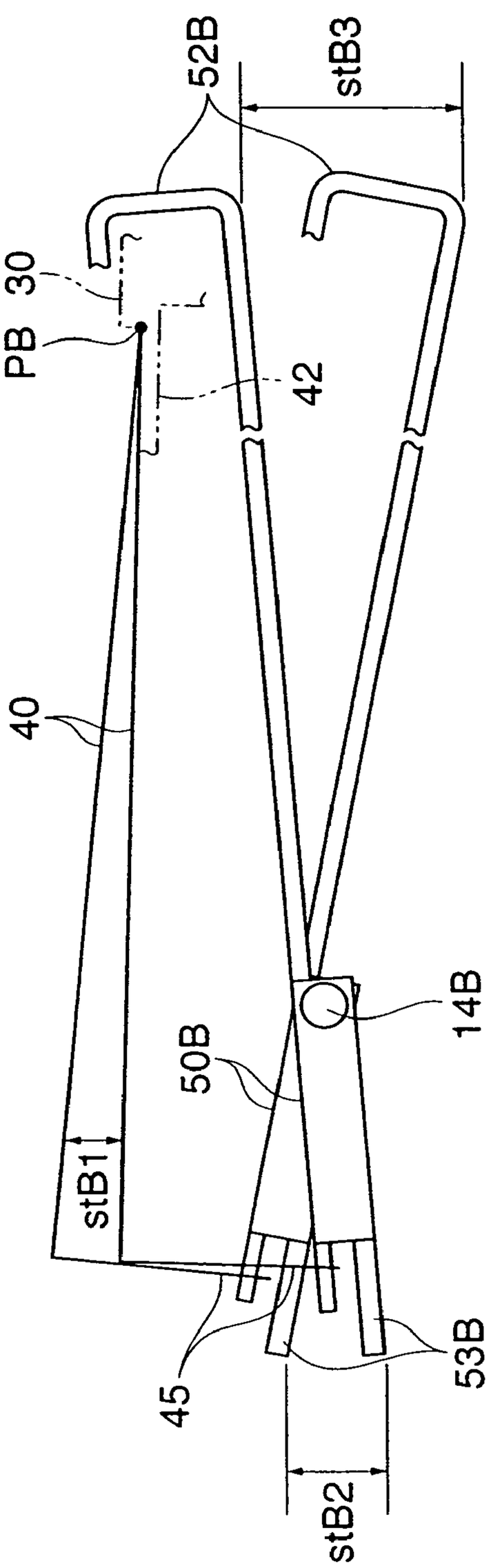

52B
stB3
PB
30
42
40
stB1
50B
14B
45
53B
stB2

FIG. 6B

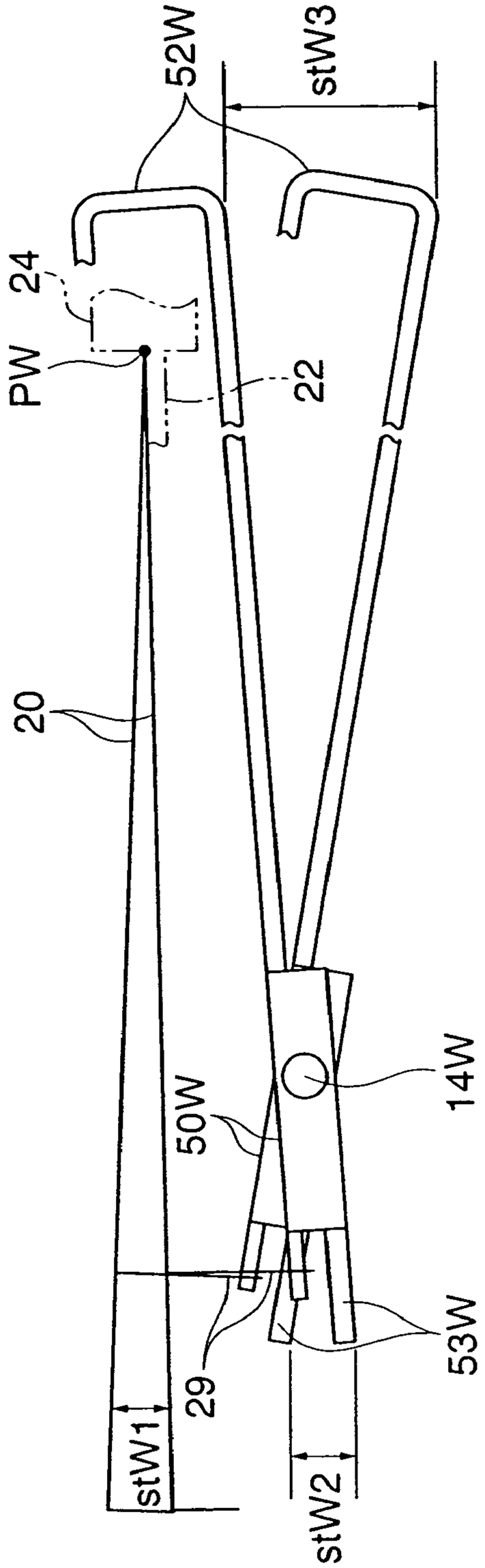
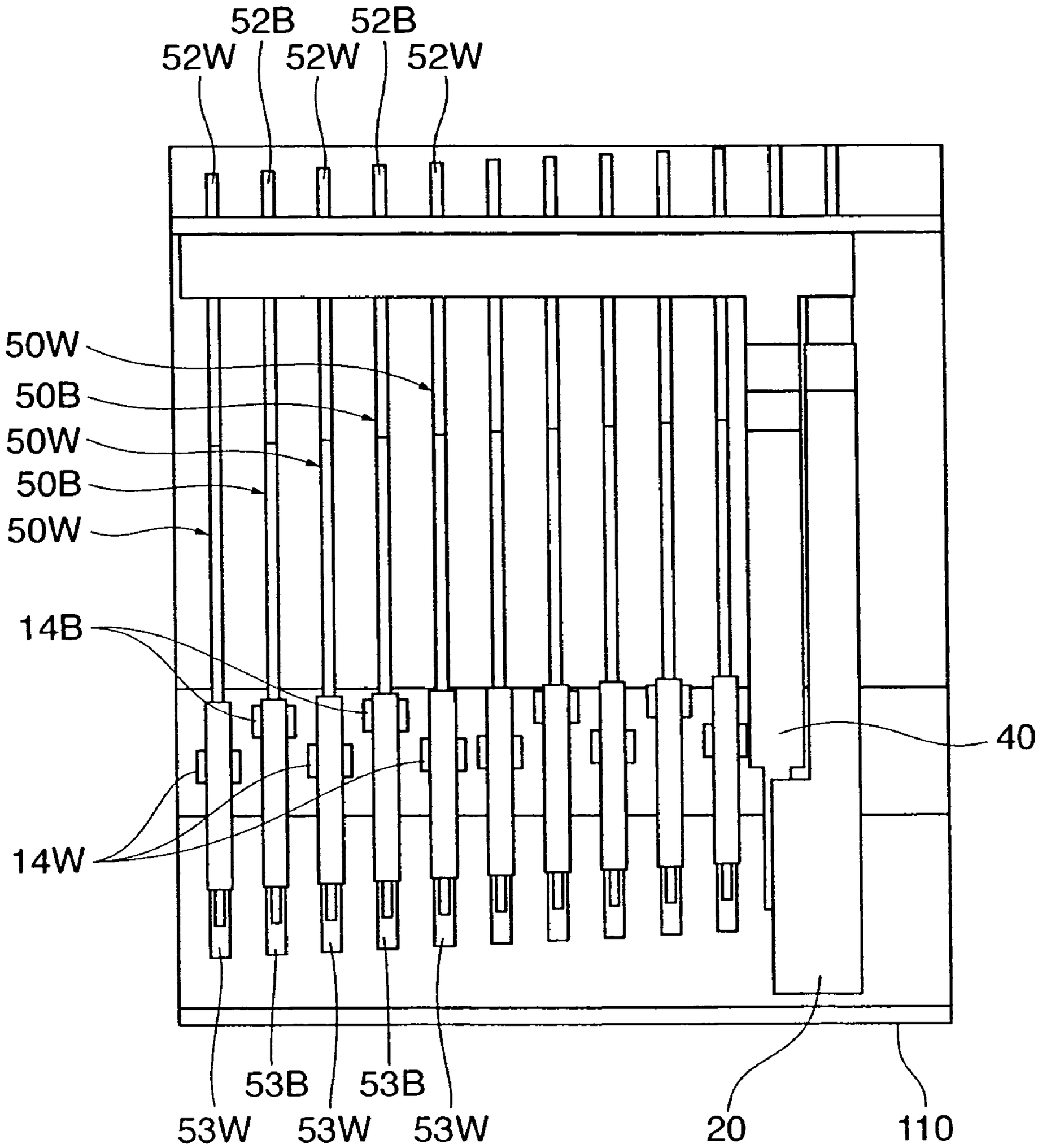

52W
stW3
PW
24
22
20
50W
14W
29
53W
stW1
stW2

FIG. 7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52B
52W
52W
52W
50W
50B
50W
50B
50W
14B
14W
40
53B
53B
53W
53W
53W
20
110

FIG. 8A

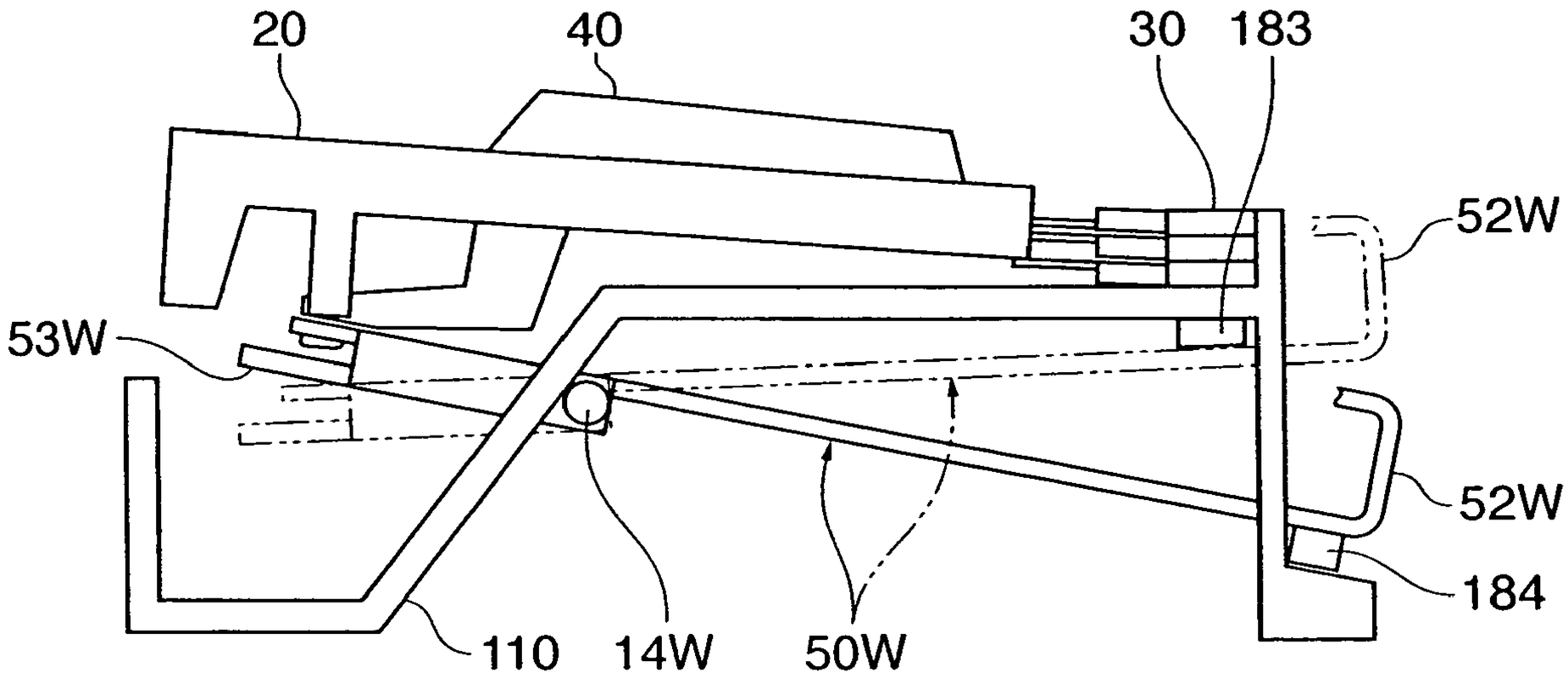
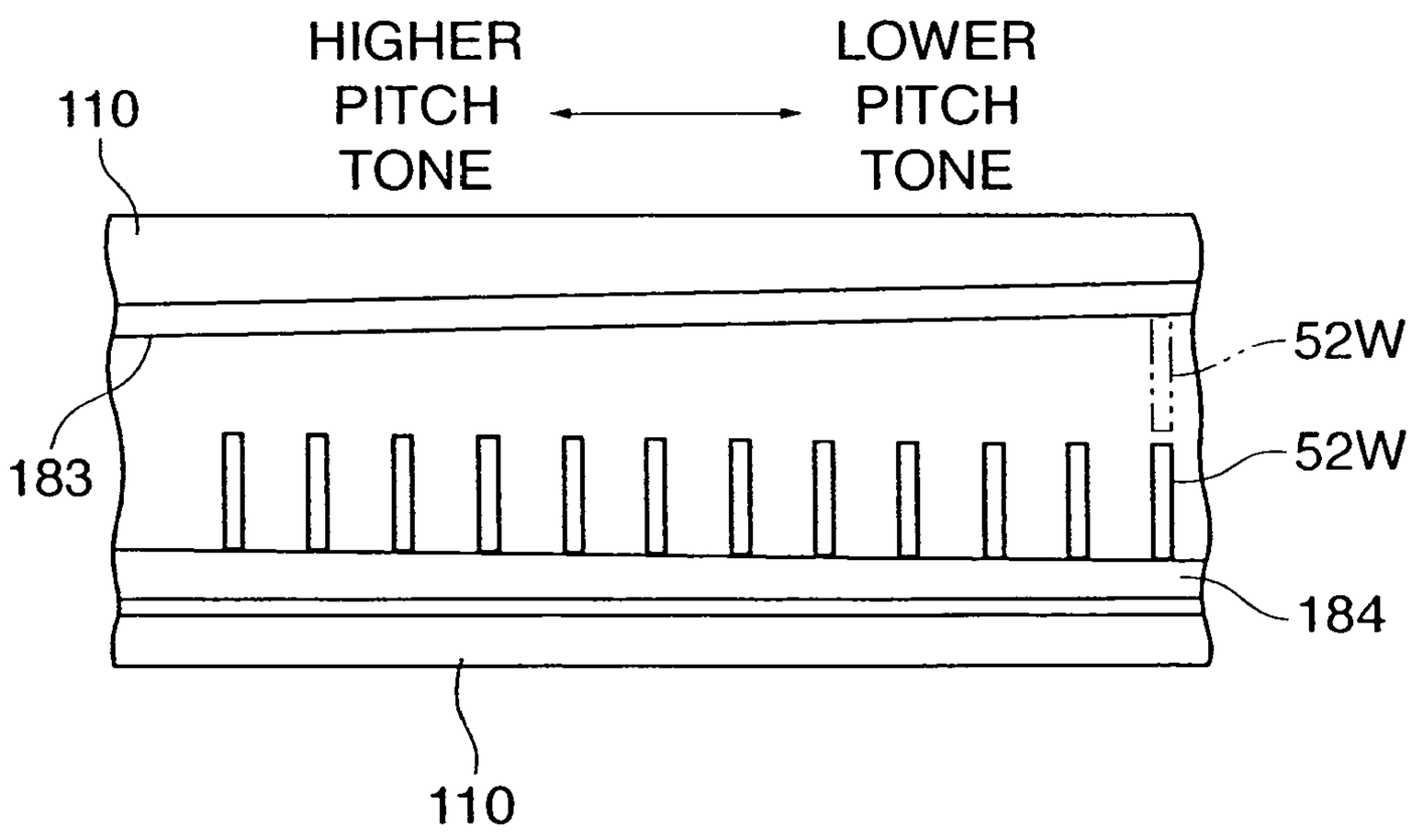

20
40
30
183
52W
53W
52W
184
110
14W
50W

FIG. 8B


HIGHER PITCH TONE
LOWER PITCH TONE
110
52W
183
52W
184
110

KEYBOARD APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a keyboard apparatus provided with pivotal members that each perform pivotal motion in accordance with a key depressing operation.

2. Description of the Related Art

In a keyboard apparatus with a keyboard of a translation type in which each key is vertically translated, it is easy to make uniform the key depression stroke and touch weight of each white key and those of each black key. However, in a keyboard apparatus configured such that each key is pivotally moved about its key pivot in the vertical direction, the distance between a portion of the key operated for key depression and the key pivot is shorter in black keys than in white keys, so that it is difficult to secure a sufficient key depression stroke for each black key without special design, and the tough weight of each black key tends to increase.

To overcome this problem, a keyboard apparatus has been proposed in which the key pivot of the black key is located rearward of that of the white key so as to keep the touch feeling of the white key and that of the black key in a somewhat more balanced state (see Japanese Laid-Open Patent Publication (Kokai) No. S60-52439).

On the other hand, keyboard apparatuses are also known in which mass bodies are mounted on a key frame or the like in a manner pivotally movable about respective pivotal motion supports, each for applying an appropriate inertial force to the associated key when the key is depressed. In a keyboard apparatus of this type, in general, when a key is depressed, a driven part of the associated mass body is driven by a driving part of the key, whereby the mass body is pivoted in accordance with the key depression.

Further, this type of keyboard apparatus provided with the mass bodies is configured, for example, such that the pivotal motion supports for all the mass bodies associated with the respective black and white keys are arranged at the same longitudinal (front-rear) location, whereas the driven part of the mass body for each black key is located forward of that of the mass body for each white key. That is, the principle of leverage is utilized to secure an appropriate key depression stroke of the black key and at the same time minimize the difference between the touch feeling of the white key and that of the black key.

However, since the driven part of the mass body for each black key is located forward of that of the mass body for each white key as described above, the length of the mass body for the black key becomes longer, and hence the space of a portion in the longitudinal direction of the keyboard apparatus where the mass bodies are to be arranged is reduced.

For keyboard apparatuses, there have been proposed various configurations of the pivotal motion support for pivotally supporting a pivotal member (a key, a mass body, or the like) which performs pivotal motion in accordance with key depression. Particularly, one of the configurations is characterized in that the pivotal motion supports are provided on ribs extending in the vertical and longitudinal directions. Further, some pivotal motion-supports are configured such that the ribs are integrally formed with a resin-made key frame by injection molding using a mold.

In this case, ribs provided for keys adjacent to each other are very close to each other, and further each rib is in the form of a flat plate. This brings about the problem that the thickness of projections and the like of the mold, for forming the respective ribs, is inevitably required to be reduced, which reduces the strength of the mold.

SUMMARY OF THE INVENTION

It is a first object of the present invention to provide a keyboard apparatus which can maintain an excellent balance in touch feeling between white keys and black keys and can be made compact in size in the longitudinal direction.

It is a second object of the present invention to provide a keyboard apparatus which can maintain an excellent balance in touch feeling between white keys and black keys and easily realize key scaling of the key-touch weight (i.e. progressive variation of the key-touch weight according to the tone pitch).

It is a third object of the present invention to provide a keyboard apparatus which can reduce the number of thin-wall portions of a mold for injection molding of a support member and enhance the strength of the mold.

To attain the above object, in a first aspect of the present invention, there is provided a keyboard apparatus comprising a support member, a plurality of keys each having a driving part, and disposed on the support member such that each key is pivotally movable about a base end part thereof, the keys comprising a plurality of white keys and a plurality of black keys, a plurality of pivotal motion supports fixedly provided on the support member, and a plurality of mass bodies provided in a manner respectively associated with the pivotal motion supports, and each having a driven part, the mass bodies being disposed in a manner pivotally movable about respective associated ones of the pivotal motion supports, and comprising white key-associated mass bodies that are associated with the white keys, respectively, and black key-associated mass bodies that are associated with the black keys, respectively, wherein the driving part of each key drives the driven part of an associated one of the mass bodies, in accordance with pivotal motion of the key, whereby the associated mass body pivotally moves about the associated pivotal motion support, and wherein the driven part of each white key-associated mass body and the driven part of each black key-associated mass body are at the same longitudinal location, and at the same time a distance between the driven part of the black key-associated mass body and the pivotal motion support associated therewith is longer than a distance between the driven part of the white key-associated mass body and the pivotal motion support associated therewith.

With the arrangement of the first aspect of the present invention, it is possible to maintain an excellent balance in touch feeling between the white keys and the black keys and make the apparatus compact in size in the longitudinal direction.

Preferably, the keyboard apparatus comprises pivotal motion range-limiting parts for limiting a range of pivotal motion of each of the mass bodies, and a distance through which a free end of each mass body moves in accordance with the pivotal motion of the mass body is made substantially equal between the white key-associated mass bodies and the black key-associated mass bodies.

With the arrangement of this preferred embodiment, it is possible to make touch weight balanced between white keys and black keys to thereby cause the touch feeling to match between the white keys and the black keys.

To attain the above object, in a second aspect of the present invention, there is provided a keyboard apparatus comprising a support member, a plurality of keys each having a driving part, and disposed on the support member

such that each key is pivotally movable about a base end part thereof, the keys comprising a plurality of white keys and a plurality of black keys, a plurality of pivotal motion supports fixedly provided on the support member, and a plurality of mass bodies provided in a manner respectively associated with the pivotal motion supports, and each having a driven part, the mass bodies being disposed in a manner pivotally movable about respective associated ones of the pivotal motion supports, and comprising white key-associated mass bodies that are associated with the white keys, respectively, and black key-associated mass bodies that are associated with the black keys, respectively, wherein the driving part of each key drives the driven part of an associated one of the mass bodies, in accordance with pivotal motion of the key, whereby the associated mass body pivotally moves about the associated pivotal motion support, wherein the pivotal motion support of each of the mass bodies is located toward one side in the longitudinal direction with respect to the driven part, wherein the pivotal motion support is disposed toward the one side in the longitudinal direction, for the black key-associated mass bodies than for the white key-associated mass bodies, and wherein as to each of the white key-associated mass bodies and the black key-associated mass bodies, the pivotal motion support of the mass body is located more toward the one side in the longitudinal direction as the mass body is of a key for a higher pitch tone, such that touch feeling of the key becomes progressively lighter from a lower pitch tone side to a higher pitch tone side.

With the arrangement of the second aspect of the present invention, it is possible to maintain an excellent balance in touch feeling between the white keys and the black keys and easily realize proper key scaling of the touch weight.

Preferably, the keyboard apparatus comprises pivotal motion range-limiting parts for limiting a range of pivotal motion of each of the mass bodies, and the pivotal motion range-limiting parts limit the range of pivotal motion of each of the white key-associated mass bodies and the black key-associated mass bodies, such that a distance through which a free end of each mass body moves in accordance with the pivotal motion of the mass body is made smaller for the mass body on a higher pitch tone side.

With the arrangement of this preferred embodiment, it is possible to make uniform the key depression strokes of the respective white keys and those of the respective black keys, to thereby improve the key scaling of the touch weight.

To attain the above object, in a third aspect of the present invention, there is provided a keyboard apparatus comprising a support member made of a resin, a plurality of support providing parts formed integrally with the support member and having a rib-like shape extending in a longitudinal direction and a vertical direction, a plurality of pivotal motion supports associated with the support providing parts, respectively, and each fixedly arranged at respective associated ones of the support providing parts, and a plurality of rotary members disposed in a manner associated with the pivotal motion supports, respectively, each for pivotally moving about an associated one of the pivotal motion supports in accordance with key depressing operation, wherein the support providing part associated with each rotary member and the support providing part associated with one of the rotary members adjacent to the rotary member at least on one of left and right sides thereof are disposed at different locations in the longitudinal direction.

With the arrangement of the third aspect of the present invention, it is possible to reduce the number of thin-wall portions of a mold for injection molding of the support member, thereby enhancing the strength of the mold.

Preferably, the pivotal motion support associated with each rotary member, and the pivotal motion support associated with one of the rotary members adjacent to the rotary member at least on one of left and right sides thereof are disposed at different locations in the longitudinal direction.

With the arrangement of this preferred embodiment, it is possible to make it easy to avoid interference between pivotal motion supports in the transverse (left-right) direction, thereby enhancing the degree of freedom of design of the pivotal motion supports.

Preferably, the rotary members each have a driven part, and are a plurality of mass bodies comprising white key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated white key and black key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated black key, the driven part of each mass body being configured to perform pivotal motion in accordance with driving of the driven part by the associated key, and the pivotal motion support of each mass body is located on one side of the driven part in the longitudinal direction, and the pivotal motion supports respectively associated with the black key-associated mass bodies are located more toward the one side in the longitudinal direction than the pivotal motion support respectively associated with the white key-associated mass bodies.

With the arrangement of this preferred embodiment, it is possible to maintain an excellent balance in touch feeling between the white keys and the black keys and make the apparatus compact in size in the longitudinal direction.

Preferably, the rotary members each have a driven part, and are a plurality of mass bodies comprising white key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated white key and black key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated black key, the driven part of each mass body being configured to perform pivotal motion in accordance with driving of the driven part by the associated key, and the support providing parts associated with respective white key-associated mass bodies are different in longitudinal location from the support providing parts associated with the respective black key-associated mass bodies, respectively.

With the arrangement of this preferred embodiment, it is possible to reduce thin wall parts of a mold for forming the support member having the support providing parts associated with the respective mass bodies, to thereby increase the strength of the mold.

The above and other objects, features, and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal cross-sectional view of a keyboard apparatus according to a first embodiment of the present invention.

FIG. **2** is a cross-sectional view of a front half of a white key.

FIG. **3** is a side view, partly in cross section, of a front half of a black key.

FIG. **4** is a fragmentary plan view of a key frame to which are assembled mass bodies.

FIG. **5** is a cross-sectional view of a front half of the key frame.

FIG. **6**A is a schematic diagram of ranges of pivotal motions of a black key and a mass body.

FIG. **6**B is a schematic diagram of ranges of pivotal motions of a white key and a mass body.

FIG. **7** is a fragmentary schematic plan view of a keyboard apparatus according to a second embodiment of the present invention.

FIG. **8**A is a schematic side view of the key frame to which are assembled mass bodies.

FIG. **8**B is a schematic rear view of the key frame in the same state as shown in FIG. **8**A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in detail with reference to the drawings showing preferred embodiments thereof.

FIG. **1** is a longitudinal cross-sectional view of a keyboard apparatus according to a first embodiment of the present invention. This keyboard apparatus **1** is configured as an electronic keyboard instrument. In the following, a player's side (left side, as viewed in FIG. **1**) of the keyboard apparatus **1** will be referred to as the "front" side.

As shown in FIG. **1**, the keyboard apparatus **1** has a key frame **10** disposed in a casing formed by an upper case **60** and a lower case **70**. In the key frame **10**, there are arranged a plurality of key units KU each comprised of a plurality of white keys **20** and a plurality of black keys **40**. Each of the key units KU has a common base end part **30** rigidly secured to the key frame **10**, and the keys **20** and the black keys **40** are each arranged such that a free end part thereof can vertically pivot (or swing).

The key frame **10** is fastened to the lower case **70** by a plurality of screws **72**, **73**, and **74**. Further, the lower case **70**, the upper case **60**, and the key frame **10** have respective front parts thereof fastened together by a plurality of bolts **71**. The lower case **70** and the upper case **60** have respective rear parts thereof fastened to each other by screwing a plurality of screws, not shown, into respective suitable portions of the lower case **70** and the upper case **60**. The lower case **70** has a lower part thereof formed with a recess **18** e.g. for accommodating batteries.

Hereafter, component elements of the keyboard apparatus **1** which are of the same kind and provided in association with the white keys **20** and the black keys **40** are each designated by the same reference numeral, but when it is required to distinguish between the association with a white key **20** and that with a black key **40**, the associated component elements of the same kind are distinguished from each other by adding "W" and "B" to the respective reference numerals.

Mass bodies **50** (**50**W and **50**B) are arranged in the frame **10** in association with the white keys **20** and the black keys **40**, respectively. Each of the mass bodies **50**W and **50**B is supported by an associated bearing **51** such that it can vertically pivot about a pivot **14** (**14**W or **14**B; described hereinafter with reference to FIG. **5**) disposed on mass body-supporting ribs **13** (**13**W or **13**B; described hereinafter with reference to FIGS. **4** and **5**) integrally formed with the key frame **10**. Almost all mass of each mass body **50** (**50**W or **50**B) is concentrated on a rear end part **52** (**52**W or **52**B) of the mass body **50** (**50**W or **50**B). The mass body **50** performs a pivotal motion in a manner interlocked with the associated key, whereby an appropriate inertia force is applied to the key to realize such a key touch as obtained from an acoustic piano.

An upper limit stopper **83** projects from an upper rear part of the key frame **10**, and a lower limit stopper **84** projects from a lower rear part of the same. The upper limit stopper **83** and the lower limit stopper **84** may be provided in association with each key, but in the present embodiment, they are commonly provided for a plurality of keys (all the keys in the apparatus or all the keys in one key unit KU, for example). The rear end part **52** of the mass body **50** comes into abutment with the lower limit stopper **84**, which defines a non-depressed position (initial position) of the mass body **50** and the associated key. On the other hand, the rear end part **52** of the mass body **50** comes into abutment with the upper limit stopper **83**, which defines a depression end position (pivotal motion end position) of the mass body **50** and the associated key.

Further, key-on switches **81** are arranged on a circuit board **80** disposed on the key frame **10**, in association with the respective white and black keys **20** and **40**. Each of these key-on switches **81** detects depression of an associated one of the keys. A tone generator, not shown, generates musical tones based on results of detection by the key-on switches **81**.

Further, a front part of the key frame **10** is formed with key guide parts **12** each for guiding the associated key being operated for depression. The key guide parts **12** are formed in association with the respective white keys **20**. Each of the white keys **20** has a front end **20***a* formed with a guided part **33** (see FIG. **2**) for engagement with an associated one of the key guide parts **12**, such that the engagement between the guided part **33** and the key guide part **12** restricts transverse movement of the front end **20***a* of the white key **20** and properly guides the same for proper vertical motion.

Though not shown in detail, one key unit KU is comprised of two white key units and one black key unit whose base end parts are laminated. Although the one key unit KU is formed as a one-octave unit, this is not limitative. The white keys **20** of the key unit KU are formed by connecting white key bodies to the common base end part **30** via respective vertical hinge parts **24** and respective horizontal hinges **22**, each in the form of a thin plate. The black keys **40** of the key unit KU are formed by connecting black key bodies to the based end part **30** via respective horizontal hinges **42** each in the form of a thin plate. The common based end part **30** is fastened to the key frame **10** by screws **82**.

The vertical hinge parts **24** permit the swinging motion of the white key **20** in the direction of arrangement of the keys (transverse or left-right direction), but the engagement between the key guide **12** and the guided part **33** properly restricts the position of the free end of the white key **20**. Further, the vertical bending of the horizontal hinge **22** makes the free end of the white key **20** pivotable in a key depression/release direction (vertical direction). Further, similarly to the horizontal hinge **22**, the vertical bending of the horizontal hinge **42** makes the free end of the black key **40** pivotable in the key depression/release direction. Strictly, the support for pivotal motion of the white key **20** is located at a connecting point PW between the vertical hinge part **24** and the horizontal hinge **22**, and the support for pivotal motion of the black key **40** is located at a connecting point PB between the common base end part **30** and the horizontal hinge **42** (see FIG. **6**). Further, the respective longitudinal centers of the horizontal hinges **22** are substantially the respective centers of pivotal motions of the white keys **20**, and the respective longitudinal centers of the horizontal hinges **42** are substantially the respective centers of pivotal motions of the black keys **40**.

FIG. **2** is a cross-sectional view of the front half of the white key **20**. FIG. **3** is a side view, partly in cross section, of the front half of the black key **40**. FIG. **4** is a fragmentary plan view of the key frame **10** to which are assembled the mass bodies **50**. FIG. **5** is a cross-sectional view of the front half of the key frame **10**.

As shown in FIGS. **4** and **5**, the key frame **10** is formed with the aforementioned mass body-supporting ribs **13**. The key frame **10** is made of resin, and is formed by injection molding using a mold. The mass body-supporting ribs **13** are integrally formed with the key frame **10** such that they extend from the upper surface of the key frame **10**, in the longitudinal and vertical directions as thin plates. The mass body-supporting ribs **13**W and **13**B are provided in respective pairs in a manner associated with the white key **20** and the black key **40**, respectively. All the mass body-supporting ribs **13**W are disposed at the same longitudinal location. All the mass body-supporting ribs **13**B are disposed at the same longitudinal location. The mass body-supporting ribs **13**B are located rearward of the mass body-supporting ribs **13**W, whereby the overlap between the two ribs **13**B and **13**W in the longitudinal direction is made small.

Further, the pivot **14**W and the pivot **14**B are suspended between each pair of mass body-supporting ribs **13**W and between each pair of mass body-supporting ribs **13**B, respectively. The pivot **14**B is located rearward of the pivot **14**W, and the two pivots **14**W and **14**B do not overlap in the longitudinal direction.

As shown in FIGS. **4** and **5**, the foremost part of the key frame **10** has the aforementioned key guides **12** integrally formed therewith in association with the respective white keys **20** such that the key guides **12** extend vertically. On the other hand, as shown in FIG. **2**, each white key **20** has the front end **20***a* thereof formed with the aforementioned guided part **33**.

As shown in FIGS. **1** and **5**, the bearings **51** (**51**W and **51**B; **51**B, not shown) of the mass bodies **50** open rearward. The bearings **51** are fitted on the pivots **14** from the open side thereof whereby the mass bodies **50**W and **50**B are made pivotable about the pivots **14**W and **14**B, respectively, as shown in FIG. **4**. When the mass body **50** is in a free state in which it is freely pivotably arranged on the pivot **14** (without having the associated key disposed thereon), it has a rear end **52** thereof brought into contact with the lower limit stopper **84** (see FIG. **1**) by its own weight, whereby the front end of the mass body **52** is in a lifted position, while the rear end **52** of the same is in a lowered position.

A tongue **56** (**56**W or **56**B) extends rearward from the lower side of the bearing **51** of the mass body **50**. The tongue **56** is made of a soft resin or the like and is flexible, and when the bearing **51** is fitted on the pivot **14**, the tongue **56** serves as a guide. Further, the opening of the bearing **51** is narrower in the vicinity of the root of the tongue **56** than in the vicinity of the foremost end of the same, whereby the pivot **14** fitted on the bearing **51** is made difficult to fall off.

As shown in FIGS. **2** to **4**, the respective foremost ends of the mass bodies **50**W and **50**B are formed with lower engaging pieces **53**W and **53**B and upper engaging pieces **54**W and **54**B which are members driven by the white key **20** and the black key **40**, respectively, and the upper engaging pieces **54**W and **54**B and the lower engaging pieces **53**W and **53**B define respective fitting recesses **55**W and **55**B therebetween (see FIGS. **2** and **3**).

Here, as to the longitudinal and vertical positional relationship between the upper engaging pieces **54**W and **54**B and the lower engaging pieces **53**W and **53**W, the upper engaging pieces **54**W and **54**B are at the same longitudinal and vertical location, while the lower engaging pieces **53**W and **53**W are at the same longitudinal and vertical position. By shifting the pivot **14**B to a more rearward location than the pivot **14**W, the distance between the lower engaging piece **53**B and the pivot **14**B is made larger than that between the lower engaging piece **53**W and the pivot **14**W (see FIG. **4**). Assuming that the mass bodies **50** whose rear ends have the same mass each perform a single or separate pivotal motion, if the lower engaging pieces **53**W and **53**B are driven, the above arrangement causes the mass body **50**B to be pivoted by a weaker driving force than the mass body **50**W due to leverage.

As shown in FIG. **2**, a hanging driving piece **29** is formed integrally with the bottom of the front part of the white key **20** such that the hanging driving piece **29** extends downward therefrom. The hanging driving piece **29** has a resilient member **31**W, made of rubber or the like, secured to a lower end thereof, and the resilient member **31**W (lower end thereof) serves as a driving part for directly driving the associated mass body **50**W. That is, when the key unit KU has been properly assembled to the key frame **10**, the resilient member **31**W is in a state fitted in the fitting recess **55**W to engage between the lower engaging piece **53**W and the upper engaging piece **54**W, so that it is always in contact with the upper surface **53**Wa of the lower engaging piece **53** and the lower surface **54**Wa of the upper engaging piece **54**W.

For example, when a white key **20** is depressed, the resilient member **31**W of the hanging driving piece **29** of the white key **20** drives the upper surface **53**Wa of the lower engaging piece **53**W of the associated mass body **50**W, whereby the mass body **50**W is pivoted in the key depressing direction (direction in which the front end of the mass body **50**W moves downward) in a manner interlocked with the white key **20**. On the other hand, when the key is released, the weight of the mass body **50**W and the returning force produced by the resilience of the horizontal hinge **22** of the white key **20** causes the mass body **50**W to pivot in the key release direction (direction in which the front end of the mass body **50**W moves upward) together with the white key **20**. Therefore, during performance operations, the white key **20** and the mass body **50**W always perform respective pivotal motions in a manner interlocked with each other.

The construction of the front end of the mass body **50**B and the engaging relationship between the black key **40** and the mass body **50**B are the same as the construction of the front end of the mass body **50**W and the engaging relationship between the white key **20** and the mass body **50**W. More specifically, as shown in FIG. **3**, a hanging driving piece **45** is integrally formed with the bottom of the front half of the black key **40** such that the hanging driving piece **45** extends downward therefrom (see also FIG. **1**). The hanging driving piece **45** has a resilient member **31**B secured to a lower end thereof, and the resilient member **31**B is fitted in the fitting recess **55**B to engage between the lower engaging piece **53**B and the upper engaging piece **54**B, so that it is always in contact with the upper surface **53**Ba of the lower engaging piece **53**B and the lower surface **54**Ba of the upper engaging piece **54**B. The actions between the black key **40** and the mass body **50**B and the operations thereof during player's performance are the same as those between the white key **20** and the mass body **50**W.

With this arrangement of the present embodiment, the mass bodies **50** and the key unit KU are assembled to the key frame **10** in the following manner: First, the bearing **51** of a

mass body **50** is fitted on the associated pivot **14** from the front side. The same assembly operation is carried out for all the mass bodies **50**.

On the other hand, a required number of key units KU (each for one octave) are formed separately in advance. Then, the key units are moved rearward from the front side to bring all the resilient members **31** of the key units KU into contact with the lower engaging pieces **53** (the upper surfaces **53**Wa and **53**Wb thereof) of the respective associated mass bodies **50**. Then, the key units KU are further moved rearward to simultaneously bring all the resilient members **31** into fitting engagement between the lower engaging pieces **53** and the upper engaging pieces **54** (fitting recesses **55**) of the respective associated mass bodies (see FIGS. **2** and **3**).

On the other hand, in parallel with the engaging operation of the resilient members **31** with the fitting recesses **55**, the respective guided parts **33** of the white keys **20** of the key unit KU naturally come into engagement with the associated key guides **12** of the key frame **10**. Then, the common base end part **30** of the key unit KU is fastened to the key frame **10** by screws **82** (see FIG. **1**). The other key units are assembled to the key frame **10** in the same manner.

In the completed keyboard apparatus **1**, the white keys **20**, the black keys **40**, and the mass bodies **50**W and **50**B pivotally move through the following ranges: FIG. **6**A is a schematic diagram of respective ranges of pivotal motions of the black key **40** and the mass body **50**B, and FIG. **6**B is a schematic diagram of respective ranges of pivotal motions of the white key **20** and the mass body **50**W.

First, as described hereinabove, the lower engaging piece **53**W and the lower engaging piece **53**B are at the same longitudinal location. Further, the mass bodies **50**W and **50**B are configured to have the same length, and the rear ends **52**W and **52**B of the mass bodies **50**W and **50**B are also at the same longitudinal location. However, as described hereinabove, the pivots **14**W and **14**B are located at respective different longitudinal locations, such that the pivot **14**B is rearward of the pivot **14**W. In this connection, the connecting points PW and PB are also located at respective different longitudinal locations, such that the connecting point PB is slightly rearward of the connecting point PW.

In the positional relationship described above, the respective ranges of rotations of the mass bodies **50**W and **50**B are limited by the upper limit stopper **83** and the lower limit stopper **84**, whereby the strokes of portions mentioned below, i.e. lengths over which the portions can travel, are as follows: First, assuming that the strokes of vertical motions of the rear ends **52**W and **52**B are represented by stW**3** and stB**3**, the strokes of vertical motions of the lower engaging pieces **53**W and **53**B by stW**2** and stB**2**, and the strokes of vertical motions (key depression strokes) of the white key **20** and the black key **40** in a region where depression of these keys often occurs by stW**1** and stB**1**. The relationship in magnitude between the above-mentioned strokes are as follows: stW**3**=stB**3**, stW**2**<stW**2**, stW**1**=stB**1**.

Here, when discussing stW**3** and stB**3**, it is assumed that the rear ends **52**W and **52**B as free ends are located at or rearward of points of contact of the mass bodies **50**W and **50**B again the upper limit stopper **83** and the lower limit stopper **84**. Strictly, stW**3** and stB**3** represent respective strokes of longitudinal travels of predetermined portions (predetermined points) of the rear ends **52**W and **52**B. Alternatively, stW**3** and stB**3** may be defined as representing longitudinal distances between the points of contact of the rear ends **52**W and **52**B against the upper limit stopper **83**, and the points of contact of the rear ends **52**W and **52**B against the lower limit stopper **84**.

Since stW**1**=stB**1** holds, the key depression strokes of the white key **20** and the black key **40** are equal to each other and balanced. What is more, since stW**3**=stB**3** holds, the touch weights of these keys sensed during respective depressions thereof are also balanced. The longitudinal location of the region wherein the depressing operation is often performed is originally different between the white key **20** and the black key **40**. However, by locating the pivot **14**B rearward of the pivot **14**W, and at the same time setting the distance between the lower engaging piece **53** and the pivot **14** such that the distance between those associated with the black key **40** is longer than the distance between those associated with the white key **20**, the white key **20** and the black key **40** are properly balanced in respect of the touch feeling (stroke and touch weight).

According to the present embodiment, it is possible to secure excellent balance in touch feeling between the white key **20** and the black key **40**. What is more, since the key depression strokes are made equal to each other, and the strokes stW**3** and stB**3** of motions of the rear ends **52** of the mass bodies **50** are made equal to each other, thereby making the key touch balanced between the white key **20** and the black key **40**, it is possible to cause the touch feeling to match between the white key **20** and the black key **40**. Further, since the mass bodies **50**W and **50**B have the same total length, and the locations of the front ends (lower engaging pieces **53**W and **53**B) and the locations of the rear ends **52**W and **52**B) coincide with each other, wasteful space is more difficult to be produced in the longitudinal direction in a region within the keyboard apparatus where the mass bodies **50** are arranged, compared with the arrangement in which the white key and the black key are made balanced in touch feeling by making them different in total length. This makes it possible to make the keyboard apparatus compact in size in the longitudinal direction.

Further, according to the present embodiment, the mass body-supporting ribs **13**B are located rearward of the mass body-supporting ribs **13**W, so that there is little overlap in the longitudinal direction between them (see FIGS. **4** and **5**). The mold for integrally forming the mass body-supporting ribs **13** with the key frame **10** by injection molding is required to be provided with thin protruding pieces each corresponding to spacing between the mass body-supporting ribs **13**W and **13**B adjacent to each other. Assuming that the mass body-supporting ribs **13**W and **13**B overlap along a wide range of area, the range of area to be provided with the thin protruding pieces increases, which lowers the strength of the mold. The mass body-supporting ribs **13**W and **13**B are often adjacent to each other due to the key arrangement of the apparatus, and hence in the present embodiment, the area of overlap of these ribs **13**W and **13**B is reduced, whereby the range of area required for provision of the thin protruding pieces is reduced, so that the strength of the mold can be increased. Incidentally, when attention is paid to the mass body-supporting ribs **13** of each key, there is no provision of more than two successive mass body-supporting ribs **13**W or mass body-supporting ribs **13**B, and hence the longitudinal locations of respective adjacent mass body-supporting ribs **13** of adjacent keys are necessarily different on at least one of the left and right side of each key. This contributes to increased strength of portions of the mold for forming the two types of mass body-supporting ribs **13**.

Further, the pivot **14**B is located rearward of the pivot **14**W, and the two do not overlap in the longitudinal direction, which makes it easier to avoid mutual interference

between the pivots **14** in the transverse (left-right) direction, whereby the degree of freedom of design of the pivot **14** can be enhanced. More specifically, it is not too much to say that in general, a pivotal motion support, as exemplified by the pivot **14**, for supporting the mass body or the like which performs pivotal motion according to the key depressing operation, receives all the forces acting during each performance operation, and hence is required to be high in strength and durability, so that the size of such a pivotal motion support naturally tends to be increased. According to the present embodiment, however, when attention is paid to each pivot **14**, the longitudinal locations of adjacent pivots are necessarily different at least on one of the right and left sides of each key and hence space is produced toward the adjacent pivot which is different in the longitudinal location. Therefore, it is possible to adopt a design in which the support mechanism protrudes into the space toward the adjacent pivot, which enhances the degree of freedom of design.

It should be noted that from the viewpoint of properly securing the balance in touch feeling between the white key **20** and the black key **40**, the longitudinal location of the lower engaging piece **53** and the distance between the lower engaging piece **53** and the pivot **14** need not be necessarily completely identical between the corresponding locations and distances of the white key **20** and the black key **40**, but they are only required to be approximately identical. The motion strokes stW**3** and stB**3**, and the key depression strokes stW**1** and stB**1** also need not be completely equal to each other.

To increase the strength of the mold, the rotary member supported by the pivotal motion support, such as the pivot **14**, is not limited to the mass body **50**. More specifically, any suitable pivotal member will suffice insofar as it is a pivotal member that pivots about the pivotal motion support according to the key depressing operation, and the pivotal member may be a key itself, or a member which is located between the key and the mass body **50** for pivotal motion. Therefore, the mass body-supporting ribs **13** as well are not necessarily required to be provided for the mass body **50**, but any rib-like members will do insofar as they are formed integrally with the key frame for supporting such pivotal members as mentioned above.

To further increase the strength of the mold, it is preferred that there is no overlap between the mass body-supporting ribs **13**W and the mass body-supporting ribs **13**B.

Now, a description will be given of a second embodiment of the present invention with reference to FIGS. **7** to **8**B.

In the first embodiment, the pivots **14**W and **14**B are made different in the longitudinal location. In the second embodiment, in addition thereto, the location of the pivot **14**W and the location of the pivot **14**B are progressively varied according to the tone pitch corresponding to each key.

FIG. **7** is a fragmentary schematic plan view of a keyboard apparatus according to the second embodiment of the present invention, in a state in which mass bodies are assembled to a key frame. FIG. **8**A is a schematic side view of the key frame to which are assembled the mass bodies, and FIG. **8**B is a schematic rear view of the same.

As shown in FIG. **7**, the longitudinal locations of the pivots **14**W and **14**B are progressively shifted rearward as the associated keys are for higher pitch tones. Therefore, as the white key **20** and the black key **40** are for higher pitch tones, they are lighter in key touch. In spite of this, the positional relationship between the pivot **14**W and the pivot **14**B is basically the same as that in the first embodiment, and the pivot **14**B is located rearward of the pivot **14**W. Therefore, the black key **40** is lighter in key touch, and hence balanced with the white key **20** in the touch weight. Incidentally, when comparison is made between the pivot **14**W of a key for a higher pitch tone and the pivot **14**B of a key for a lower pitch tone, the longitudinal location is sometimes inverted. However, at least considering the positional relationship between two pivots **14**W and **14**B adjacent to each other, the pivot **14**B is located more rearward than the pivot **14**W, so that there is no odd feeling as to the touch weigh which varies with the tone pitch.

The key frame **110** is distinguished from the key frame **10** only in that the locations of the mass body-supporting ribs **13**W and **13**B, not shown, progressively vary in accordance with the locations of the pivots **14**W and **14**B which progressively vary with the tone pitch, but is constructed similarly to the same in the other respects. Further, the mass bodies **50**W and **50**B themselves have the same constructions as those in the first embodiment, respectively and the longitudinal locations thereof vary with the locations of the pivots **14**W and **14**B. Therefore, the locations of the lower engaging pieces **53**W and **53**B and rear ends **52**W and **52**B are also different from those in the first embodiment, depending on the arrangement of the mass bodies **50**W and **50**B. Further, the key unit KU is different from that of the first embodiment in that the locations of the hanging driving pieces **29** and **45** and the location of the resilient member **31**, none of which are shown, are different in accordance with different locations of the lower engaging pieces **53**W and **53**B of the mass bodies **50**W and **50**B, but is constructed similarly in the other respects.

By the way, although the key touch is configured to be made lighter as the key is for a higher pitch tone, assuming that the movable range of the rear end **52** of the mass body **50** is identical for all the mass bodies **50**, the key depression stroke is made shorter as the key is for a lower pitch tone. Therefore, in the present embodiment, in place of the upper limit stopper **83** and the lower limit stopper **84** which are at respective uniform levels in the first embodiment, the key frame **110** is provided with upper limit stoppers **183** and lower limit stoppers **184** which vary in level from one mass body **50** to another, as shown in FIGS. **8**A and **8**B.

As shown in FIG. **8**B, the bottom surface of the lower limit stopper **183** is higher as the associated key is for a lower pitch tone, and the top surface of the lower limit stopper **184** is lower as the associated key is for a lower pitch tone. More specifically, as the key is for a lower pitch tone, the distance between the upper limit stopper **183** and the associated lower limit stopper **184** becomes larger, and hence the stroke of motion of the rear end **52** of the mass body **50** is longer as the associated key is for a lower pitch tone. With this arrangement, the key depression stroke in a region where the white key **20** and the black key **40** are depressed very frequently is made uniform for all the keys.

By the way, if the keys in the entire frequency range are continuously subjected to the aforementioned progressive variation in the locations of the pivots **14**W and **14**B according to the tone pitch, the longitudinal length of the keyboard apparatus **1** becomes too large. To overcome the problem, the aforementioned progressive variation is repeated for each frequency range (one octave) corresponding to the key unit KU and at the same time grade (mass) of the used mass bodies **50** is made different from one frequency range to another. For example, in a second frequency range higher than a first frequency range by one frequency range, the grade of the mass bodies **50** is lowered (made lighter) by one stage, and the progressive variation pattern of the pivot **14** in the longitudinal direction is made identical to

that in the first frequency range. Therefore, the leftmost pivots **14** in the respective frequency ranges are at the same longitudinal location. It should be noted that the progressive variation pattern is not necessarily required to be repeated for each frequency range corresponding to the key unit KU, but may be repeated on a several octaves-by-several octaves basis, or on a several keys-by-several keys basis.

The present embodiment provides the same advantageous effects as provided by the first embodiment in that the touch feeling is well balanced between the white key **20** and the black key **40**, and at the same time the keyboard apparatus **1** is made compact in size in the longitudinal direction of the apparatus. Furthermore, it is possible to easily realize key scaling of the touch weight (progressive variation in the touch weight according to the pitch). What is more, the distance between the upper limit stopper **183** and the lower limit stopper **184** is varied with the tone pitch, whereby the stroke of key depression is made uniform between the white keys **20** and between the black keys **40**. This makes the touch feeling of a depressed key appropriate according to the tone pitch. These can be made possible without making the mass bodies **50** different on a key-by-key basis, and hence the key scaling of all keys is made possible with a smaller number of types of mass bodies **50**.

In the second embodiment, only from the viewpoint of realizing the key scaling dependent on the touch weight, the lower engaging pieces **53** of all the mass bodies **50** may be at the same longitudinal location, and at the same time the mass bodies **50**W and **50**B may be made longer in the distance between the lower engaging piece **53** and the pivot **14** as they are associated with keys for higher pitch tones.

Although in the first and second embodiments, the lower engaging piece **53** of the mass body **50** is located forward of the pivot **14** by way of example, this is not limitative, but the orientation of the mass body **50** may be inverted in the longitudinal direction, and the free end may be directed frontward, differently from the above-described embodiments. In this case, it goes without saying that the positional relationship between the lower engaging piece **53** and the pivot **14** of each mass body **50** is inverted, but also between the mass bodies **50**W and **50**B, the positional relationship between the pivots **14**W and **14**B and that between the lower engaging pieces **53**W and **53**B are also inverted in the longitudinal direction.

Although in the first and second embodiments, the key units KU each integrating a plurality keys therein are used, this is not limitative, but keys may be provided separately or independently of each other.

What is claimed is:

1. A keyboard apparatus comprising:

a support member;

a plurality of keys each having a driving part, and disposed on said support member such that each key is pivotally movable about a base end part thereof, said keys comprising a plurality of white keys and a plurality of black keys;

a plurality of pivotal motion supports fixedly provided on said support member; and

a plurality of mass bodies provided in a manner respectively associated with said pivotal motion supports, and each having a driven part, said mass bodies being disposed in a manner pivotally movable about respective associated ones of said pivotal motion supports, and comprising white key-associated mass bodies that are associated with said white keys, respectively, and black key-associated mass bodies that are associated with said black keys, respectively,

wherein said driving part of each key drives said driven part of an associated one of said mass bodies, in accordance with pivotal motion of said key, whereby said associated mass body pivotally moves about said associated pivotal motion support, and

wherein said driven part of each white key-associated mass body and said driven part of each black key-associated mass body are at the same longitudinal location, and at the same time a distance between said driven part of said black key-associated mass body and said pivotal motion support associated therewith is longer than a distance between said driven part of said white key-associated mass body and said pivotal motion support associated therewith.

2. A keyboard apparatus as claimed in claim **1**, comprising pivotal motion range-limiting parts for limiting a range of pivotal motion of each of said mass bodies, and wherein a distance through which a free end of each mass body moves in accordance with the pivotal motion of said mass body is made substantially equal between said white key-associated mass bodies and said black key-associated mass bodies.

3. A keyboard apparatus comprising:

a support member;

a plurality of keys each having a driving part, and disposed on said support member such that each key is pivotally movable about a base end part thereof, said keys comprising a plurality of white keys and a plurality of black keys;

a plurality of pivotal motion supports fixedly provided on said support member; and

a plurality of mass bodies provided in a manner respectively associated with said pivotal motion supports, and each having a driven part, said mass bodies being disposed in a manner pivotally movable about respective associated ones of said pivotal motion supports, and comprising white key-associated mass bodies that are associated with said white keys, respectively, and black key-associated mass bodies that are associated with said black keys, respectively,

wherein said driving part of each key drives said driven part of an associated one of said mass bodies, in accordance with pivotal motion of said key, whereby said associated mass body pivotally moves about said associated pivotal motion support,

wherein said pivotal motion support of each of said mass bodies is located toward one side in the longitudinal direction with respect to said driven part,

wherein said pivotal motion support is disposed toward the one side in the longitudinal direction, for said black key-associated mass bodies than for said white key-associated mass bodies, and

wherein as to each of said white key-associated mass bodies and said black key-associated mass bodies, said pivotal motion support of said mass body is located more toward the one side in the longitudinal direction as said mass body is of a key for a higher pitch tone, such that touch feeling of the key becomes progressively lighter from a lower pitch tone side to a higher pitch tone side.

4. A keyboard apparatus as claimed in claim **1**, comprising pivotal motion range-limiting parts for limiting a range of pivotal motion of each of said mass bodies, and said pivotal motion range-limiting parts limit the range of pivotal motion of each of said white key-associated mass bodies and said black key-associated mass bodies, such that a distance through which a free end of each mass body moves in

accordance with the pivotal motion of said mass body is made smaller for said mass body on a higher pitch tone side.

5. A keyboard apparatus comprising:

a support member made of a resin;

a plurality of support providing parts formed integrally with said support member and having a rib-like shape extending in a longitudinal direction and a vertical direction;

a plurality of pivotal motion supports associated with said support providing parts, respectively, and each fixedly arranged at respective associated ones of said support providing parts; and

a plurality of rotary members disposed in a manner associated with said pivotal motion supports, respectively, each for pivotally moving about an associated one of said pivotal motion supports in accordance with key depressing operation,

wherein said support providing part associated with each rotary member and said support providing part associated with one of said rotary members adjacent to said rotary member at least on one of left and right sides thereof are disposed at different locations in the longitudinal direction.

6. A keyboard apparatus as claimed in claim **5**, wherein said pivotal motion support associated with each rotary member, and said pivotal motion support associated with one of said rotary members adjacent to said rotary member at least on one of left and right sides thereof are disposed at different locations in the longitudinal direction.

7. A keyboard apparatus as claimed in claim **5**, wherein said rotary members each have a driven part, and are a plurality of mass bodies comprising white key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated white key and black key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated black key, said driven part of each mass body being configured to perform pivotal motion in accordance with driving of said driven part by the associated key, and wherein said pivotal motion support of each mass body is located on one side of said driven part in the longitudinal direction, and said pivotal motion supports respectively associated with said black key-associated mass bodies are located more toward the one side in the longitudinal direction than said pivotal motion support respectively associated with said white key-associated mass bodies.

8. A keyboard apparatus as claimed in claim **5**, wherein said rotary members each have a driven part, and are a plurality of mass bodies comprising white key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated white key and black key-associated mass bodies that each pivotally move in accordance with a key depressing operation of an associated black key, said driven part of each mass body being configured to perform pivotal motion in accordance with driving of said driven part by the associated key, and wherein said support providing parts associated with respective white key-associated mass bodies are different in longitudinal location from said support providing parts associated with said respective black key-associated mass bodies, respectively.

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